KISHINOUYE'S ORDER PLECOSTEI

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 50

UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

Explanatory Note

The series embodies results of investigations, usually of restricted scope, intended to aid or direct management or utilization practices and as guides for administrative or legislative action. It is issued in limited quantities for the official use of Federal, State or cooperating agencies and in processed form for economy and to avoid delay in publication.

Washington, D. C.
January 1951

United States Department of the Interior
Oscar L. Chapman, Secretary
Fish and Wildlife Service
Albert M. Day, Director

Special Scientific Report - Fisheries
No. 50

KISHINOUYE'S ORDER PLECOSTEI

Translated from the Japanese language by

W. G. Van Campen

Pacific Oceanic Fishery Investigations

CONTENTS

Page

1. A new order of the teleostomi, By Kamakichi Kishinouye 1/..... 1

2. On the order plecostei established by Dr. Kishinouye, By Nisuke Takahashi, Dr. Agr. 2/..... 3

1/ From Suisan Gakkai Hō, Vol. 2, No. 2. November 1917.

2/ From the Zoological Magazine [Dōbutsugaku Zasshi] (Vol. 36) No. 432, pp. 397-408. October 15, 1924.

A New Order Of The Teleostomi

Since the publication of the first volume of this journal I have from time to time presented papers on the anatomy, classification, and distribution of the cybiids, tunas, and bonitos. I am still continuing my researches on these fishes, but as a result of the studies made up to this time I have come to the conclusion that it is necessary to change the present classification to a degree even greater than that which I have suggested previously. Accordingly I wish to record my conclusions in outline as follows.

There is a great difference between the fishes which have the dark red muscle tissue (chiai) close to the central axis of the body and those fishes which do not, and this difference is truly a clearly marked one. For this reason I wish to separate the former from the Teleostei and establish them as a new Order of the Teleostomi, to which I give the name of Plecostei. The fishes of this Order I wish further to divide into the families Thunnidae and Katsuwonidae. The classification of these fishes given in Number 1 of Volume 1 of this journal is to be changed so that the family Thunnidae as defined therein becomes the new Order, the genus Thunnus is raised to the rank of a Family, the Thunnidae, and the genera Katsuwonus, Euthynnus, and Auxis are combined into the family Katsuwonidae.

The new order Plecostei is closely related to the families Scombridae, Istiophoridae, and Cybiidae among the Acanthopterygii of the Teleostei, being closest to the Scombridae in particular. The members of this Order are the most advanced of all the fishes. For these reasons I believe that the Teleostomi should be classified as follows:

	Crossopterygii
	Chondrostei
Teleostomi	Holostei
	Teleostei
	Plecostei

PLECOSTEI

These fishes can be easily and clearly distinguished from the other Orders of the Teleostomi by the presence of well developed cutaneous blood vessels. With the development of this vascular system there is an increased supply of capillaries to the tissues on each side of the spinal column, forming the dark red part called the chiai. There is a large blood supply and consequently the heart is large. The bones of the vertebral column are very closely articulated, and their zygapophyses are developed dorsoventrally and anteroposteriorly. The inferior foramina which appear in the bases of the haemal arches are large and the passage for the blood vessels is broad with a sort of latticework formed ventral to the spinal column. This is especially pronounced in the skipjack.

In these fishes the lateral muscles invariably extend to the dorsal surface of the head with their anterior ends coinciding with the anterior edges of the frontal bones. In many cases the kidneys enter the haemal canal where they run posteriorly, a characteristic which is not often seen in other fishes.

These species are said to be the most active and swiftest swimmers among all of the fishes because their bodies offer the least resistance to the water, their muscles are remarkably well developed, and their skeletal structure permits only a lateral movement at the base of the tail. It is also said that their blood is warm and that they maintain their own body temperature.

Although these fishes differ in their cutaneous vascular systems and in the dark red lateral tissue developed in relation to these systems, and in their kidneys and the vascular systems within the kidneys, they are very close on all other points to the genera Gymnosarda and Sarda of the family Cybiidae of the Acanthopterygii.

Family Thunnidae

The whole body is covered with scales. The first vertebra is very thin and is fused to the cranium. A number of the thoracic vertebrae have lateral processes. The second dorsal is ordinarily higher than the first dorsal or is of at least equal height. The three lobes of the liver are roughly equal in size and shape, and the intestine forms one loop. There are pyloric caeca which are located only on the posterior side of the duodenum. The cutaneous vessels pass through the myotomes of the fifth or seventh vertebrae, and the dorsal and ventral branches are joined anteriorly over the intermuscular bones of those myotomes, while posteriorly they are joined over the 31st or 32nd vertebra. They are joined by transverse branches to the great artery which runs along the central axis of the body. The cutaneous arteries either join the great artery or join directly to the Cuvierian ducts. A long branch of the kidneys enters the haemal canal, but the portion of those organs which lies between the peritoneum and the ribs is short. The ureters are separated into left and right branches only anteriorly. These fishes are generally large, attaining lengths of more than 3 feet.

Family Katsuwonidae

There are almost no scales except on the corselet. The vertebrae have no lateral projections, and the first vertebra is thick. The second dorsal is markedly lower than the first dorsal. The right lobe of the liver is slender and, except in the genus Katsuwonus, long, reaching almost to the anus. The intestine is straight and has no loops. There are pyloric caeca on both sides of the duodenum. The cutaneous vessels of the genus Katsuwonus pass through the myotome of the third vertebra with the inferior branch passing anterior to the first rib. In the other genera they traverse the myotome of the fifth vertebra and there are no inferior branches. In short, there is nothing which corresponds to the inferior branches of the cutaneous vessels in the Thunnidae. In all of these fishes

except those of the genus Katsuwonus there are rather large vessels between the base of the pectoral and the anus, but these are not related to the dark lateral tissue. The anterior end of the cutaneous vein divides into the renal portal veins and does not connect directly with the Cuvierian ducts. No part of the kidneys appears in the haemal canal except in the genus Katsuwonus and the portion of the kidneys which lies between the peritoneum and the ribs is long, running almost the full length of the visceral cavity. Although it is generally a single organ which lies along the very center line of the body, in the genus Auxis it divides posteriorly into two slender branches. The ureters generally open separately in right and left branches. Anteriorly the tips of the intermuscular bones reach to the subcutaneous tissue, but posteriorly a number of them are divided into two parts. On one or more of the vertebrae the intermuscular bones and the ribs are joined at their bases. An air bladder is lacking. The fishes of this family are generally small, under three feet in length.

On The Order Plecostei Established By Dr. Kishinouye

TN: In the descriptions of the specialized vascular systems of the tunas written in English by Kishinouye and quoted in this paper in the original language by Takahashi, these vessels are consistently characterized as "cutaneous." The corresponding word in the Japanese text, however, is more accurately translated as "subcutaneous" and since that seems to be a more exact description of the actual location of these vessels, the latter terminology has been followed in this translation.

The figures which are described at the end of this paper were not clear enough to be copied for reproduction and had to be omitted.

Introduction

In 1915 Dr. Kamakichi Kishinouye published a paper in the first Volume of the Suisan Gakkai Hō in which he discussed the anatomy, distribution, and so forth, of the tunas, bonitos, and cybiids. He established the three families of the Thunnidae, Cybiidae, and Scombridae. He assigned the genera Thunnus, Katsuwonus, Euthynnus, and Auxis to the Thunnidae, the genera Acanthocybium, Cybium, Sarda, and Gymnosarda to the Cybiidae, and the genera Scomber, Rastrelliger, and Grammatorcynus to the Scombridae. He reported that the fishes of the family Thunnidae have the dark lateral muscle tissue developed close to the central axis of the body and further that the fishes of this family have peculiar subcutaneous blood vessels on the sides of the body. Then in 1917 in the second Volume of the same journal, under the title "A New Order of the Teleostomi", he split the Thunnidae into two families, the Thunnidae and the Katsuwonidae.

To the former he assigned the genus Thunnus and to the latter the genera Katsuwonus, Euthynnus, and Auxis. Then on the basis of the fact that the fishes of these two families possess the peculiar subcutaneous blood vessels mentioned above and have the dark lateral tissue, with its vascular plexuses, close to the spinal column, he separated them completely from the Teleostei and set them up as a new Order called the Plecostei. He published the following table of the classification of the Teleostomi with its accompanying description of the Plecostei:

"This Order can be easily and clearly distinguished from the other fishes of the Teleostomi by the presence of well-developed subcutaneous vessels. With the development of these vessels there is a supply of capillary plexuses to the tissues on each side of the spinal column forming the dark red portion called the chiai, etc."

The table of classification which Kishinouye gave is as follows:

Teleostomi	Crossopterygii
	Chondrostei
	Holostei
	Teleostei
	Plecostei

He had this further to say about the relationship between the Plecostei and the Teleostei (where the term Teleostei is used without qualification in what follows, it is used in Kishinouye's sense of the term):

"The fishes of the new Order Plecostei are closely related to the Scombridae, Istiophoridae, and Cybiidae among the Acanthopterygii of the Teleostei, being particularly close to the Cybiidae. These are the most advanced of fishes."

In 1923 Kishinouye published in Number 3 of Volume 8 of the Journal of the College of Agriculture of the Tokyo Imperial University a treatise on the Plecostei. He described as follows the main points on which he differentiated this Order from the rest of the Teleostomi:

[in English]

"Group of teleostomatous fish, having a cutaneous vascular system, connected with vascular plexus developed as sheets in the lateral muscle. Portions of the lateral muscle surrounded by these sheets of the vascular plexus are situated on both sides of the vertebral column, and are dark red, nearly black in color. Another peculiar vascular plexus is developed on the inner side of the liver or in the haemal canal. Moreover the circulation of blood in the liver is especially well developed."

As he explained in the foregoing, Kishinouye lumped the Thunnidae and the Katsuwonidae together and separated them from the Order Teleostei as previously defined to form the new Order Plecostei. I have studied various teleostean fishes to find out whether or not it is true, as he definitely stated, that the subcutaneous blood vessels which are the most outstanding

characteristic of the Plecostei are not found in the Teleostei. I found that, contrary to Kishinouye's theory, various teleostean fishes have these vessels. Consequently I arrived at the conclusion that there was no longer any reason for the setting up of this new Order on an equal rank with the other Orders of the Teleostomi listed above. In what follows I will give a detailed exposition of my stand.

I. An Outline of the Subcutaneous Blood Vessels of the Plecostei as Described by Kishinouye

Before showing that the subcutaneous vessels are not peculiar to the Plecostei but are found in various teleostean fishes, it is necessary for the purposes of the argument that I show just what it was that Kishinouye was describing when he wrote about these vessels. Therefore I shall first quote selected passages from his paper in the Journal of the College of Agriculture of the Tokyo Imperial University, Vol. 8, No. 3, in order to give a general account of these subcutaneous vessels.

a. The Relation Between the Subcutaneous Arteries and the Dorsal Aorta

/in English/

"The cutaneous arterial system consists of one or two large trunks running near the lateral median line of the body, originating in the pectoral region, behind the pharyngeal muscle from the dorsal aorta."

b. The Subcutaneous Arteries of the Thunnidae

/in English/

"In the Thunnidae the cutaneous artery runs obliquely backward and downward, passing behind the third (Thunnus) or fifth (Parathunnus and Neothunnus) rib, and reaches the surface of the body before the intermuscular bone, attached above the root of the respective rib. Before reaching the surface of the body each artery is split into two equal branches, running dorsal and ventral to the lateral median line, nearly parallel to each other. They are united again in the caudal portion by a transverse ran commissure, and the commissure is again united to the dorsal aorta by a pair of horizontal segmental arteries."

c. The Subcutaneous Arteries of the Katsuwonidae

/in English/

"In the Katsuwonidae, the cutaneous artery of the epaxial side would be homologous to both the epaxial and hypaxial branches of the cutaneous artery of the Thunnidae. The hypaxial cutaneous artery of the Katsuwonidae is remarkably short and slender, it generally originates in front of the epaxial artery, and takes a forward direction, and after passing through the kidney turns backward; it is situated in a more ventral portion than the hypaxial branch

of the cutaneous artery of the Thunnidae. In Katsuwonus the epaxial and hypaxial arteries are nearly equal and originate from common lateral branch of the dorsal aorta, in the hind part of the segment of the sixth vertebra, just behind the pharyngeal muscle.

In Euthynnus and Auxis there are two pairs of cutaneous arteries originating from two different points. The anterior pair is smaller, homologous to the hypaxial limb of the cutaneous artery of Katsuwonus, and is given off from the body segment of the sixth vertebra. The artery takes a more or less forward direction, passes through the kidney and then turns forward. The artery has no relation with the dark red muscle. The posterior pair is very thick, nearly as the dorsal aorta or a little thicker than it, probably homologous to the whole cutaneous artery of the Thunnidae. The posterior pair of cutaneous arteries takes an obliquely upward and backward direction, and makes its appearance at the surface of the body, between the intermuscular bones of the fourth and fifth vertebrae."

d. The Subcutaneous Veins of the Thunnidae

/in English/

"In the genus Thunnus, the most primitive type of the Plecostei, the cutaneous system is best developed, and the vertebral system is abortive, the posterior cardinal vein being wanting. A short, slender caudal vein is found in the place of the posterior cardinal vein. The caudal vein joins at the middle part to the transverse commissure of the cutaneous veins and thus communicates indirectly with the Cuvierian ducts. A pair of cutaneous veins, are found on each side of the body, on the epaxial and hypaxial sides of the lateral median line. These two veins run almost parallel, and quite near each other. They run deep into the myotome of the fourth vertebra, at the hind margin of the myotome, and unite a little below the surface of the body. The confluent vessel runs obliquely anteriorly, passes under the proximal slender part of the third rib, joins the Cuvierian duct of the respective side, after collecting many renal venules. The right and left cutaneous veins are united by a transverse commissure in the caudal portion. This transverse commissure of cutaneous veins is found in all the forms of the Thunnidae.

In Parathunnus the cutaneous veins of both sides pass through the myotome of the sixth vertebra, and each uniting to a large vein running below the fifth rib, pour into a transverse canal behind the pharyngeal muscles. The transverse canal joins the right Cuvierian duct after uniting with a short renal vein.

In Neothunnus the cutaneous veins are united by an anterior transverse commissure as in Parathunnus, or sometimes each of them pours directly into the Cuvierian duct of the respective side as in Thunnus."

e. The Subcutaneous Veins of the Katsuwonidae

/in English/

"The cutaneous veins do not join the Cuvierian duct directly, nor are they united by a transverse vessel in the thoracic region to the posterior cardinal vein, but are divided to renal portals. Thus the cutaneous veins differ from the similar veins of the Thunnidae. Moreover the lower cutaneous vein of this family is not homologous to the lower branch of the cutaneous vein of the Thunnidae. The epaxial and hypaxial veins originate in different myotomes and they do not form a loop at the caudal region, nor are they connected by the transverse commissure. In Katsuwonus the epaxial and hypaxial cutaneous veins are nearly equal in size and length, and though they are not straight they are nearly equally distant from the median line of the body. These veins run anteriorly and to a deeper part of the body, passing through the myotome of the fifth vertebra. The epaxial vein passes below the first rib, while the lower passes over it. These two veins receive blood respectively from the sheets of the vascular plexus on the dorsal and ventral sides of the dark red portion of the lateral muscle. In the other genera, Euthynnus and Auxis, the epaxial cutaneous vein is very thick and runs close and parallel to the lateral median line of the body, running to the deeper part of the body between the myotomes of the fourth and fifth vertebrae. The chief cutaneous segmental veins are united to the epaxial cutaneous vein, and sheets of vascular plexus surrounding the dark red portion of the lateral muscle are connected with vein. The hypaxial cutaneous vein is remarkably short, slender, and zigzag in its course, disappearing from the surface of the body just behind the postclavicle and before the myotome of the first vertebra. In Katsuwonidae the hypaxial cutaneous vein always passes before and above the first rib."

On the basis of these quotations from the original description, the subcutaneous vessels may be roughly described as follows. These vessels are under the skin on the sides of the body, originate near the pectoral girdle, run longitudinally and posteriorly, and consist of either one or two homologous or non-homologous vessels. Ordinarily these vessels reach the vicinity of the caudal peduncle, but there are some cases in which they disappear posterior to the pectoral girdle. In many cases these vessels have vascular plexuses which are related to the dark red lateral tissue of the fish, but in some cases these are completely lacking. The arteries are ordinarily simply branches of the dorsal aorta, but the veins are remarkably rich in variations and their relations with the Cuvierian ducts, the renal portal veins, and the cardinal veins show numerous variations as between species, individuals, and even between the two sides of a single specimen.

Furthermore, according to Kishinouye, in the yellowfin tuna (Neothunnus macropterus) of the family Thunnidae one vessel originating from the subcutaneous artery and one vessel originating from the fourth efferent branchial artery join to form a single vessel, while in the genera Auxis and Euthynnus of the Katsuwonidae an anterior and posterior branch from the dorsal aorta sometimes join to form a single subcutaneous artery.

II. The Subcutaneous Vessels are Homologous With the Segmental Vessels

In all fishes the dorsal aorta and the cardinal vein give off pairs of left and right segmental vessels in each myotome and these vessels and their ramifications are as a rule distributed over the tissues of the sides of the fish. However, as is characteristic of vascular systems in general, ordinarily the relative positions of these arteries and veins and the pattern of their ramifications show variations as between species, individuals, and the various parts of individuals.

Now before discussing the relationship between the segmental vessels and the subcutaneous vessels I will for the sake of convenience describe briefly the vessels of the second myotome in the common mackerel (Scomber japonicus) and the vessels of the third myotome of the sailfish (Istiophorus orientalis) after which I will make a comparison between these vessels and the subcutaneous vessels of the Plecostei.

The mackerel which I have examined have had eleven pairs of segmental arteries in their bodies. The second of these vessels branches off from the dorsal aorta directly under the fourth vertebra and immediately posterior to the retractor arcus branchialis dorsalis superior (the "pharyngeal muscle" of Kishinouye). The vessel immediately proceeds outward, passes through the peritoneum at the base of the rib of the fourth vertebra and then between the third and fourth myotomes along the intermuscular bones, dividing into anterior and posterior branches along the way. The posterior branch proceeds to a point directly ventral to the nerve of the lateral line where it further divides into two dorsal and ventral branches. The dorsal branch proceeds posteriodorsally and toward the outer surface of the body, while the ventral branch proceeds posterioventrally and toward the surface of the body. These vessels run along the inner side of the dark lateral tissue belonging to the third and fourth myotomes and then issue forth into the subcutaneous tissues posterior to the pectoral girdle, where they become finely divided. In other specimens which I have seen these vessels send off one or two branches near their bases.

Now when we compare the segmental vessels of the second myotome in the mackerel (sa, sav, sad in figure 5) and the subcutaneous vessels of the black tuna (Thunnus orientalis) or the Koshinaga (Neothunnus rarus) (ca, eca, hca in figure 1), they are almost identical in their most important points, that is in the relationships of the pectoral girdle, spinal column, intermuscular bones (intercostals), myotomes, nerves of the lateral line, dark red lateral tissue, and the retractor arcus branchialis dorsalis superior muscle, and in the direction and branching pattern of the vessels. The only point on which they differ is that in the former the dorsal and ventral branches formed by the fork in the vessel ventral to the nerve of the lateral line are short, while in the latter they are long. If these ventral and dorsal branches in the former were only more markedly developed and if they ran parallel to the axis of the body through the subcutaneous tissues, they would present exactly the same condition as the latter. And if these vessels in the mackerel did not split into dorsal and ventral branches and continued to run longitudinally under the skin, or if the ventral branch were to

degenerate and disappear and the dorsal branch to develop longitudinally, they would present exactly the same situation as that seen in the posterior part of the subcutaneous arteries in the genera Euthynnus and Auxis of the family Katsuwonidae. (cap in Fig.2). The same explanation can be given of the relationship between the subcutaneous veins and the segmental veins.

In the sailfish [Istiophorus orientalis] all of the segmental vessels make their appearance in the subcutaneous tissues along the lateral median line of the body whence they proceed posteriorly along the boundaries between the myotomes and soon disappear. The arteries originate from the dorsal aorta and ordinarily run anterior to the veins, and the capillaries [?] branch off from the great vein, the renal portal veins, and the caudal vein.

Now when we compare the segmental vessels of the third myotome of this species (Figure 4 sa, sv) with the posterior part of the subcutaneous vessels of the genus Auxis as described by Kishinouye (Figure 2 cap, ecv), there is no marked difference except that the vessels of the former are shorter and smaller than those of the latter. For this reason, if the vessels of the third myotome in the former were prolonged until they reached the caudal portion of the body, and at the same time the rest of the segmental vessels were hidden within the lateral muscles, they would present an identical condition with the posterior part of the subcutaneous vascular system in the latter. Furthermore, the anterior part of the subcutaneous arteries in the genus Auxis is almost identical with the arteries of the second myotome in the sailfish.

In view of these facts, the subcutaneous vascular system is homologous with the segmental system, of which it is merely a marked development in the subcutaneous tissues. Accordingly the subcutaneous vessels and the segmental vessels do not differ fundamentally but only in the degree of their development, and they are bascially identical.

III. Do Differences in the Size of Blood Vessels Have Any Value as the Principal Characteristics of Orders in the Taxonomy of Fishes?

No other part of the internal organs of animals is as rich in variations as the vascular system, a fact which is recognized by all comparative anatomists and which needs no further discussion.

Kishinouye regarded the presence of the subcutaneous vascular system as the only major characteristic of the Plecostei, but, as shown above, the subcutaneous vessels and the segmental vessels are identical in origin, differ only in size, and do not differ at all basically. If this is so, is it possible after all for a difference in the degree of development, or in other words in the size and length, of anything as prone to marked variations as the vascular system to be the main characteristic of an Order? In particular is it possible to consider such a characteristic as having a taxonomic value equal to or greater than the differences which exist between the other Orders of the Teleostomi such as the Crossopterygii, the Chondrostei, and the Holostei? These are propositions on which there is room for a good deal of doubt.

IV. There Are Fishes Which Have Subcutaneous Vessels Among the Teleosts Also.

Kishinouye stated repeatedly that the subcutaneous vessels are found only in the Plecostei and that they are lacking in the Teleostei, however, according to the results of my studies there are many teleostean fishes which have subcutaneous vessels almost identical with those of the Plecostei in the degree of their development and on other points. In what follows I will cite several examples.

a. Swordfish (Xiphias gladius L.) (Figure 3) (Xiphiidae)

In this species, as in the Plecostei, the dark red lateral tissue is close to the spinal column. On the sides of the body near the lateral line there are subcutaneous vessels consisting of one artery and one vein. These vessels appear in the subcutaneous tissues directly posterior to the pectoral girdle and run longitudinally as far as the tip of the tail [?]. In an individual 150 cm long the artery and vein are respectively approximately 1 mm and 1.5 mm in diameter. The artery lies along the dorsal external side of the vein. Both vessels send out small branches into the dark red lateral tissue forming vascular plexuses like those of the Plecostei.

Unfortunately I cannot make any statement at the moment about the relationship between the subcutaneous vessels in this species and the main vascular system, that is the dorsal aorta and the great vein, because when these great fish are taken, the gills and other internal organs are immediately removed so that the carcass can be packed with ice and the fish are brought to market with the main blood vessels already removed.

b. Dolphin (Coryphaena hippurus L.) (Figure 7) (Coryphaenidae)

This species possesses only the subcutaneous veins. These vessels appear in the subcutaneous tissues immediately posterior to the pectoral girdle and run along the lateral line as far as the tip of the tail [? caudal peduncle?]. These vessels appear to branch off from the Cuvierian ducts.

c. Aomishimaokoze (Gnathagnus elongatus (T. et S.)) (Figure 6) (Uranoscopidae)

This species has both subcutaneous arteries and veins. The arteries branch off near the base of the subclavicular artery, pass beneath the pectoral girdle, issue immediately to the subcutaneous tissues, and parallel the lateral line as far as the tail. The veins come out of the kidneys, pass beneath the pectoral girdle, issue thence directly to the subcutaneous tissues, and proceed posterioventrally to a point between the ventral fin and the anus.

d. Mutsugorō (Apocryptes chinensis Osbeck) (Gobiidae)

This species has only the subcutaneous veins. The vessels branch off from the sinus venosus and proceed to the vicinity of the dorsal fin.

e. Torafugu (Sphaeroides rubripes T. et S.) (Tetraodontidae)

This species has only the subcutaneous veins. The vessels originate from the kidneys and run posteriorly, ending near the anus.

The examples cited above show clearly that, although there are various differences as between species, there are teleostean fishes which have remarkably developed subcutaneous blood vessels.

V. The Subcutaneous Blood Vessels of the Plecostei and of the Teleostei Are in the Broad Sense Identical.

Although Kishinouye claimed that subcutaneous blood vessels are lacking in the Teleostei and are found only in the Plecostei, if the subcutaneous blood vessels are as he described them it would be very unreasonable to deny their existence in teleostean fishes. As explained above, there are among the Teleostei many species having vessels which present the same conditions seen in the subcutaneous vascular systems of the Plecostei. Furthermore the differences between the vessels seen in these teleosts and the subcutaneous vessels of the Plecostei are much slighter than the differences between the subcutaneous vessels of certain species within the Order Plecostei (for example between Thunnus orientalis and Auxis maru). Although it has been impossible for the reasons given above to find out the points of origin of the subcutaneous arteries and veins in the broadbill swordfish, in all other respects these vessels are identical respectively with the posterior part of the subcutaneous arteries and with the dorsal subcutaneous veins of the genus Auxis.

The subcutaneous veins of Gnathagnus elongatus are completely identical with the ventral subcutaneous veins of the genera Auxis and Euthynnus, and although the subcutaneous arteries of the former differ with regard to their point of origin from the posterior subcutaneous arteries of the latter, they are completely identical on all other points.

The subcutaneous veins of the dolphin, except for the fact that they are simple and that the left and right vessels are joined at their posterior ends, are on all other important points completely identical with the subcutaneous veins of the genus Thunnus.

The subcutaneous veins of Sphaeroides rubripes are identical with the dorsal subcutaneous veins of the genera Euthynnus and Auxis.

Even though the subcutaneous vessels of the teleostean fishes cited as examples here are not in the strict embryological sense identical with those of the Plecostei, there is no obstacle to regarding them both as the same and calling them both subcutaneous vessels according to the writings and views of Kishinouye. This is because Kishinouye himself lumped together nonhomologous vessels and vessels which differ markedly in their areas of distribution, conditions of origin, and relations to the dark red lateral tissues and applied to all comparatively conspicuous vessels which appear in the subcutaneous tissues in the vicinity of the

pectoral girdle and run posteriorly the term "subcutaneous vessels."

If one takes the position that because the subcutaneous vessels of the Teleostei are not homologous with those of the Plecostei, the teleosts do not have subcutaneous vessels, why then did Kishinouye apply the term subcutaneous vessels to nonhomologous vessels in the Plecostei? And furthermore, supposing that the subcutaneous vessels of the teleosts and those of the Plecostei cannot be regarded as identical embryologically, then insofar as there is no embryological proof regarding the subcutaneous vessels of the various species of the Plecostei it is not in a strict sense permissible to say that they are homologous vessels. The reason for this is that in vertebrates in the case of the segmental vessels, vertebral nerves, myotomes, and similar parts which as a rule form a segmental arrangement it is not generally possible without some embryological facts for a basis to consider as homologous things which occur in different body segments. For example, it cannot be denied that there is a great deal of room for doubt as to whether the subcutaneous vessels which comes out from beneath the fifth vertebra in Thunnus germo and that which originates under the ninth vertebra in Neothunnus macropterus are after all embryologically homologous.

Further supposing that the subcutaneous artery of Gnathagnus elongatus described above does differ from that of the Plecostei and that, because it does not originate directly from the dorsal aorta, it cannot be called a subcutaneous vessel, then it must be made clear why all of the subcutaneous veins of the Plecostei are called subcutaneous veins regardless of the striking differences in their points of origin and their relationships to the major vessels.

Since as a matter of fact the subcutaneous artery of Gnathagnus elongatus does not originate directly from the dorsal aorta but rather from the basal portion of the subclavicular artery, it may perhaps be that it is not fundamentally identical with the subcutaneous arteries of the Plecostei, however, considering the question from the opposite point of view, blood vessels are generally prone to variation and it is not at all strange that homologous vessels should differ greatly as between species and markedly as between individuals.

Now to give a few examples of such variation, in the ruminants and the Perissodactyla the left and right subclavicular arteries and the cervical arteries are fused in their basal portions to form a truncus communis. In the carnivores, marsupials, and in swine only the left subclavicular artery is separate from the truncus communis, while in the Chiroptera, porpoises, and Neophocaena phocaenoides the right and left subclavicular arteries, although they are fused at their bases to the corresponding cervical arteries, do not form a common trunk as in the animals mentioned above. In man, the anthropoid apes, the duckbilled platypus, seals, the Edentata, and the fin whale the basal portions of the right subclavicular artery and the corresponding cervical artery are joined into a single vessel while the same vessels on the left side are completely separate.

The most common example among fishes is that seen in the relationship of the coeliac artery and the mesenteric artery. In some species (for example the ribbon-fish /Trichiurus haumela/ and the cod) these vessels originate quite independently from the dorsal aorta, while in other species (such as Thunnus orientalis and the deep-sea bass /Niphon spinosus/) they are joined to form the coeliaco-mesenteric artery. Furthermore, the positional relationships of the points of origin of this coeliaco-mesenteric artery and of other arteries such as the subclavicular are remarkably variable. In the deep-sea bass the coeliaco-mesenteric originates at a point anterior to the subclavicular while in Thunnus and Auxis it originates posterior to the subclavicular.

According to Kishinouye's researches, in the genera Euthynnus and Auxis the anterior and posterior subcutaneous arteries originate as two separate vessels from the dorsal aorta, while in Katsuwonus they are not separate but form at first a single common vessel originating from the dorsal aorta and then divide later into two vessels. Also according to his descriptions and figures the points of origin of the subcutaneous veins in one species of Thunnidae, the yellowfin tuna, are remarkably variable.

In view of what has been said above about the variability of blood vessels it is not at all unreasonable to assume that in some individuals of Gnathagnus elongatus the basal portions of the subcutaneous arteries and the subclavicular arteries, which originate immediately anterior to them, may be fused together. If this assumption is allowed, it may be said that the subcutaneous arteries of this species and of the Plecostei are identical. And even supposing that the subcutaneous arteries in this species are not homologous with those of the Plecostei, it goes without saying that since the subclavicular artery is originally a kind of segmental artery, the subcutaneous arteries of this species, which are branches of the subclavicular, should also be classed as segmental arteries. Accordingly it should require no further argument to show that the subcutaneous arteries /in the Plecostei/, which are just highly developed segmental arteries, should be considered to belong to the same system.

On the basis of the preceding arguments there is no obstacle, either in Kishinouye's own views or from the point of view of comparative anatomy, to saying that the subcutaneous vessels of the Plecostei and of the Teleostei are in the broad sense identical.

VI. Subcutaneous Vessels Are not Peculiar to the Plecostei.

As explained above, the subcutaneous vessels of the Plecostei are comparatively conspicuous developments of the segmental vessels of the anterior portion of the body and are not in the least a new system peculiar to the Plecostei. Furthermore, as shown above there are various species of teleostean fishes which possess subcutaneous vessels developed like those of the Plecostei, and therefore it goes without saying that these vessels are not, as Kishinouye categorically affirmed, a peculiarity of the Plecostei.

VII. Summary and Conclusion

When Kishinouye in 1917 in Volume 2 of the Suisan Gakkai Hō first introduced the new Order of Plecostei, he gave as its primary characteristic the presence of subcutaneous blood vessels and as its secondary characteristic the position close to the spinal column of lateral areas of dark red tissue with vascular plexuses. In 1923 in Volume 8, Number 3, of the Journal of the College of Agriculture of the Tokyo Imperial University he added as another secondary characteristic the development of vascular plexuses within the body cavity.

Kishinouye decided that these features of the Plecostei could be considered of equal weight with the differences between the other Orders of the Teleostomi, such as the Crossopterygii, Chondrostei, Holostei, and Teleostei, separated the Plecostei completely from the Teleostei as then constituted, and set them up as a new Order. Now that the subcutaneous vessels, which are the principal characteristic of this Order, have been discovered in various teleosts and have been clearly proven not to be peculiar to the Plecostei, the latter have lost the main reason for their status as a distinct Order. Consequently the point has been reached where this Order should be abandoned. Now that the main characteristic has been lost it will naturally be completely impossible to maintain the continued existence of the Order solely on the basis of the secondary characteristics. It is probably unnecessary to say any more about the matter, but I would like to point out as a preliminary to any discussion that the presence of vascular plexuses in the dark lateral tissue and the position of this tissue close to the spinal column as described by Kishinouye can also be seen in the broadbill swordfish, a teleostean species, and are not in the least peculiar to the Plecostei. The positional relationship between the spinal column and the dark lateral tissue is particularly subject to striking variations in the sharks. As for the vascular plexuses in the body cavities of the Plecostei, circumstances have prevented my having as yet had an opportunity to ascertain by an examination of many species of teleostean fishes whether or not such plexuses occur also in teleosts, and consequently I cannot at the moment decide this question, but there is room for doubt as to their not occurring in any species of the Teleostei. However, even assuming that these vascular plexuses are not to be found in any teleost and that they a re peculiar to the Plecostei, it cannot be said that this single feature should be considered a character equal in weight to those which differentiate the other Orders of the Teleostomi. If this single feature has a value great enough to separate the Plecostei from the Teleostei as hitherto constituted, then what of the Weberian apparatus of the cyprinids?

If the person who established this Order wishes to insist upon its continued existence for the reason that these vascular plexuses have not yet been discovered in teleostean species, then he must explain in detail why it is that special organs like those of the cyprinids referred to above do not have sufficient value to set that group of fishes apart from the teleosts as a new Order while only these vascular plexuses, which belong to the highly variable vascular system, do have such value. If such an explanation cannot be given or if the explanation is unreasonable, then the

Order Plecostei should naturally be discarded. In short, the Order Plecostei, which is established solely on the basis of a partial variation in the highly variable vascular system, and actually only in the minor details of that system, cannot exist in an equal status with the other four Orders of the Teleostomi and should therefore be thrown out.

In conclusion I wish to express my heartfelt thanks to my teacher, Professor Chiyomatsu Ishikawa, for his constant encouragement and for his valuable advice in the gathering of my material and the writing of this paper.

Explanation of Figures

Figure 1 koshinagashibi (Neothunnus rarus Kishinouye)

Part of the subcutaneous vein and part of the muscle tissue anterior to the sixth myotome have been cut away, and the small vessels originating from the subcutaneous vessels have been omitted.

Figure 2 marumejika (Auxis maru Kishinouye) [round frigate mackerel]

Vessels originating from the subcutaneous vessels have been omitted.

Figure 3 mekajiki (Xiphias gladius L.) [broadbill swordfish]

Parts of the opercle and the pectoral girdle have been cut away, and the small vessels originating from the subcutaneous vessels have been omitted.

Figure 4 bashōkajiki (Istiophorus orientalis T. et S.) [sailfish]

The ventral portion of the lateral muscle tissue has been cut away.

Figure 5 saba (Scomber japonicus Houttuyn) [mackerel]

The third myotome has been cut away and the small vessels originating from the segmental vessels have been omitted.

Figure 6 aomishimaokoze (Gnathagnus elongatus T. et S.)

All of the pectoral girdle and a part of the opercle have been cut away.

Figure 7 shiira (Coryphaena hippurus L.) [dolphin]

Part of the pectoral girdle has been cut away.

Explanation of Abbreviations Used in the Figures

a. dorsla aorta	ca subcutaneous artery
cv subcutaneous vein	d dark lateral tissue
ecv epaxial subcutaneous vein	hca hypaxial subcutaneous artery

i	intermuscular bone (intercostal	cap	posterior subcutaneous artery
p	pectoral fin	hcv	hypaxial subcutaneous vein
sv'	second segmental vein	sa'	second segmental artery
sa"	third segmental artery	sav'	ventral branch of the second segmental vein
sv"	third segmental vein	k	kidney
eca	epaxial subcutaneous artery	s	subclavicular artery
n	nerves of lateral line	sod'	dorsal branch of second segmental artery

Works Consulted

1. Boulenger, G.A. -- Fishes. Cambridge Nat. Hist., VII, London, 1904.
2. Bridge, T.W. -- Cambridge Nat., VII, London, 1904
3. Hatta, S. -- Uber die Entwicklung des Gefassystems des Neuaugens, Lampetra mitsukurii Hatta. Zoologische Jahrbuchern, Bd. 44, Abt. f. Anatomie, 1922.
4. Kishinouye, K. -- Studies on the mackerels, cybiids, and tunas. Suisan Gakkai Hō, Vol.1, No.1, 1915.
5. _____ A new Order of the Teleostomi. Suisan Gakkai Hō, Vol.2, No.2, 1917.
6. _____ Contribution to the comparative study of the so-called scombroid fishes. Jour. Coll. Agr. Tokyo, VIII, 3.1923.
7. Lankester, E.R. -- A treatise on zoology, part IV. Vertebrata Craniata. London, 1909.
8. Nuhn, A. -- Lehrbuch der vergleichenden Anatomie. Heidelberg, 1886.
9. Wiederscheim, R. -- Vergleichende Anatomie der Wirbeltier. Jena, 1909.